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ABSTRACT

Factor analysis and multiple regression are two major approaches used to look at functional age, which takes account of the extensive variation in the rate of physiological and psychological maturation throughout life. To examine the role of racial or cultural influences on the measurement of functional age, a battery of 12 tests concentrating on cognitive and perceptual-cognitive variables, and a background information questionnaire were administered to 81 White and 84 minority (25 Blacks, 59 Hispanics) adults. Principal components factor analysis was conducted on the battery of tests for the entire subject pool, and for the whites and minorities separately. Multiple regression analysis was performed, regressing chronological age on the test battery. The results from these two analyses suggest the appearance of differing factor structures and regression equations between the minority and white subsamples. In addition, they suggest that results from pooled sample analyses may not be representative of the separate subsample analyses. It may be concluded from these data that the statistical procedures used to define functional age yield results which are not invariant across ethnic groups, and this may call into question the generality of the procedures used to assess functional age. (NRB)

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A Factor Analytic and Regression Approach to Functional Age: Potential Effects of Race[1]

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Introduction

Definition of Functional Age

It has been nearly twenty-one years since McFarland proposed the idea of functional age. He reported that when talking about airline pilots, "the important variable to consider is not chronological age, but functional age or the ability to perform required duties efficiently and safely" (McFarland, 1953). He recognized, as did others before him, the extensive variation in the rate of physiological and psychological maturation throughout life. In this early article, he expressed his dismay with the use of chronological age as a reliable index of an individuals physical and mental development. Others have also expressed the same concern. Costa and McCrae (1981) for example, emphasize the small amount of explanatory power in an index of chronological age, used as an index of the underlying causal process of change in somatic and psychological systems and structures that we call aging. At best, it is a rough approximation.

Clearly, there is tremendous variation among individuals at a given age level in a variety of physical, physiological, and psychological capacities and abilities. Functional Age (as ideally proposed) takes account of differential "decay" of these different systems. This idea is captured very well by Nuttall's (1972) notion of "nearness to death". By definition, a person who is near to the end of his life is functionally old, while another person who is quite distant from the end of his life is functionally young. Because of differential rates of aging in the various systems among individuals (for whatever the cause), two individuals with identical chronological ages may be functionally quite different. Thus, persons with functional ages (computed in some ideal manner), greater than their respective chronological ages, are said to

be nearer to death than would be indicated by their chronological ages (and visa versa).

Variables Used to Define Functional Age

McFarland admitted in his original article that little had been done concerning the measurement of functional age. However, he did recognize the importance of not only the age-relatedness of physiological functions, but also the potential impact of a person's "highly personal set of experiences, infections, intoxications, and mental and emotional reactions and stresses during a lifetime." Bouliere (1970) also stresses the importance of these types of variables in determining one's functioning. Since McFarland's original article, a few notable attempts have been made to measure or "bring to life" empirically the notion of functional age. Most noteworthy is Dirken's (1972) study of Dutch industrial workers, Nuttall and his colleagues' Boston V.A. Outpatient Clinic studies (see overview by Bell, 1972), and Heron and Chown's (1967) study in England. These studies are consistent in that the researchers attempted to measure a wide variety of variables assessing different age-dependent systems (physiological, anthropometric, psychological, etc.), totalling 34 variables in the Boston V.A. study (final battery), 70 in the Dirken study, and 39 in the study by Heron and Chown. In the final analysis, functional age was represented by 12 variables in the Boston V.A. study (variables representing their six aspects of functional age), 21 variables from the Dirken study (with heavy emphasis on physiological indices and equally lighter emphasis on cognitive and perceptual variables), and 16 variables from the Heron and Chown study (with approximately equal representation of cognitive, perceptual, personality, and physiological variables.

The Emergence of Functional Age

After the identification of all of the important areas of functioning and measurement of important indicators of each, it becomes necessary to commit oneself to to an approach which will yield some usable index or indices of functional age. Costa and McCrae (1981) make a very important point concerning the utility of the functional age concept by referring to its practicality. In order to be practical, any index of functional age should show generality and economy as does chronological age, and that multiple indices of functional age defeats the purpose of a unitary replacement concept. There have been two major approaches used in looking at functional age: Factor Analysis and Multiple regression.

Factor analysis is a term which generally represents a great number of techniques involved in attempting to understand or describe common underlying dimensions in a matrix of intercorrelation. Some techniques are aimed mainly at reducing a large set of variables to some smaller, relatively independent, more manageable set (e.g., Principal Components Factor Analysis). The majority of factor analysis techniques attempt to understand the underlying dimensionality of a set of variables (these refer to the wide variety of Common Factor Analysis Techniques). All of the functional age studies described above used factor analysis techniques (specifically, principal components analysis) for this first purpose (data reduction). The Boston V.A. studies (e.g., Nuttall, 1972) used factor analysis to represent functional age. Their early studies revealed (using regression analyses) six different functional ages: Social Age, Anthropological Age, Personality Age, Ability Age, Auditory Age, and Laboratory Age. Nuttall (1973) then hypothesized that a factor analysis of the

original 31 variables (defining the six dimensions), would lead to the emergence of six major factors. Principal Components Analysis with varimax rotation was carried out. Twelve factors with eigenvalues greater than 1.0 were extracted, however, a scree plot indicated four factors accounting for 30% of the variance. These factors were named: Functional Age, SES, Strength, and Size respectively. In addition, chronological age loaded .82 on the first factor, and the factor structure remains essentially unchanged without chronological age in the analysis. Nuttall takes this as evidence that the functional age factor is completely defined without using chronological age. Variables loading highly on this factor were: Greyness of the hair, three measures of perceptual-cognitive ability and air conduction hearing, in addition to chronological age. The Boston V.A. studies did not use scores on this first factor as functional age scores. In deriving the distinct functional age dimensions, they used the regression approach (discussed below).

The most widely used technique for measuring functional age is Multiple Regression. The objective is to again assemble ones final battery of tests, and to use these tests to predict chronological age. The rationale is stated very clearly in Dempster (1972). "The linear composite of variables should be chosen to correlate most strongly with functional age, but functional age is not available, so we use high correlation with actual age as the criterion, and hope the effect of using the wrong criterion is minor. The statistical age thus found is an empirical estimate of functional age" (p. 195). What is of interest here is the variation unrelated to chronological age, or the deviations of actual ages around the predicted age regression line. It is hypothesized that deviations of actual age from predicted age represents functional superiority

or inferiority with respect to a persons true chronological age. Dirken (1972), as well as other researchers (Nuttall and his colleagues at the Boston V.A. studies), have used this approach. Dirken computed a variety of regression equations, most yielding multiple R's in the .85 - .90 range using variables representing the four broad classes of variables (work physiological, psychological, sensory, and psychomotor). He also provides elaborate corrections for the regression to the mean phenomenon. Nuttall and his colleagues used test batteries composed of a number of different types of variables to predict chronological age yielding the six different functional ages: Auditory, Laboratory, Social, Personality, Anthropological, and Ability Ages.

It is not the purpose of this paper to critique the viability of each approach to the measurement of functional age. There are also other approaches; for example, profile analysis used by Heron and Chown and also used by Dirken (these procedures do not yield a single estimate of functional age or predicted chronological age). There is considerable controversy concerning the will not be addressed. Given the assumption of choice of one or both of these above methods of assessing functional age, what is the role of racial or cultural influences on this measurement process?

Cultural Effects

The sample used in the studies by Dirken, Heron and Chown, and Nuttall and his colleagues seemed to be remarkably homogeneous with respect to race and cultural background. A major question that comes to mind when considering, aspects of the aging process is the role that culture plays in "influencing" or reflecting another influence on the aging process. The influence of culture and cultural

differences upon cognition and intellectual structure and growth cannot be ignored (see Greenfield and Bruner, 1966; Cole et al., 1971, and Cole and Bruner, 1971 for example). In developmental research in general, there has been considerable concern for cultural differences among "old" and "young" (in a cohort sense) subjects in cross-sectional studies of development. This is the controversy between those theorists favoring cross-sectional vs. longitudinal designs and the cohort group problem. For example, Botwinick (1967) reviews studies looking at structural differences in intellect between older and younger individuals. Conclusions reached clearly show differences in factorial structure (e.g., of the WAIS) between the different age groups. A more recent study by Cunningham and Birren (1980) also confirms these results.

While it is true that there are structural differences between groups, the source of these differences is the main concern. While age differences are undoubtedly important (at least the structural change process of which the passage of calendar time is symbolic), most agree that educational differences (and other differences as well) are also important. Indeed, the studies reviewed above by Botwinick confirm this.

Because of the heterogeneity and the relatively small sample size of the sample employed in the current study, this cohort group influence on the measurement of functional age will not be looked at. However, a different, perhaps more direct cultural effect may be present. Culturally distinct subsamples are present within our sample (Black, White, and Hispanics). Our concern is that (with the aim of assessing its effect on the measurement of functional age), the structure of the perceptual-cognitive abilities tapped by our measures will differ across these intact ethnic groups. We are specifically concerned with

whether or not the factor structure of our battery of tests will be different for the ditferent ethnic groups (especially the possibility of different variables defining the first factors) and whether the regression equations predicting chronological age will be different (different variables defining the equations and/or different weights of the same variables). Finally, what implications will these differences have on the current state of measurement of functional age?

This research began by looking at the potential predictive or concurrent validity of functional age (looked at using both approaches) for predicting job performance (see Solley, Santos, and Stagner, 1984 for a review of this analysis). Self ratings of job performance were obtained. Functional age was first calculated using the regression approach. Subjects were then split into two groups: those having functional ages greater than versus less than their respective chronological ages. These groups were found to differ significantly on self ratings of job performance with the group having higher functional ages than their respective chronological ages perceiving their job performance to be worse (problems with this analysis will not be discussed here). Factor analysis of the battery was then carried out to identify variables loading highly on the first factor. These variables were then used to predict self evaluations of job performance. While prediction was found to be quite good, different prediction equations were found for whites vs. minorities (the variables carried different weights). Similarly, separate factor analyses showed that different variables defined the white and minority first factors, and that the pooled first factor did not seem to be representative of either of the white or minority subsamples. These analyses seemed to indicate an ethnic influence on factor structures and regression equations for predicting self evaluation of

job performance. This influence may also show up in the process of measuring functional age.

Thus, it is the thesis of this paper that the statistical procedures used to define functional age yield results which are not invariant across ethnic groups, and that this may call into question the generality of the procedures used to assess functional age. In addition, the question of possible consequences of using such a measure of functional age (e.g., for purposes of making decisions regarding treatment, placement, and retraining of older workers) will be discussed in the discussion and conclusions section.

Method

Subjects

Subjects were recruited in Detroit Michigan and Las Cruces New Mexico through the UAW Retirement Centers. Other subjects were recruited directly from classes at Wayne State University, and the participating MARS program (Mature and Returning Students). At present, usable data is available from 81 whites, 25 blacks, and 59 hispanics. The rationale was to approximate the demographic characteristics of the metropolitan area. Because of the disproportionately small number of blacks and hispanics, these two groups were pooled to form white and minority subgroups.

Procedure

The battery of tests used in this research consists of thirteen subtests (including a background information questionnaire) nine of which were administered using an interactive program on a small portable personal computer. Testing time for each subject approximated two hours. Cognitive and perceptual-cognitive variables were the concentration of the battery. In

addition, a variety of background information was collected. The current battery is generally representative of other batteries used in previous research with the exception of physiological measures (see Solley, Santos, and Stagner, 1984, for a full description of the test battery).

Because of the small sample sizes, the total battery of tests was reduced to a smaller manageable battery, while still attempting to maintain the integrity of the overall battery. Separate factor analyses of the perceptual-cognitive and background variables were conducted toward this aim. In addition, variable variances, intercorrelations, and communalities were examined. Another criterion kept in mind when making these decisions was multicollinearily of the retained variables. Interpretation of the results of multivariate analyses is very dangerous when predictor variables are substantially intercorrelated. Thus, there was a concerted attempt to keep this at a minimum. The final battery of twelve tests is shown in Table 1. The following subtests were retained for the final battery: Vocabulary and Backward Digit Span subtests of the WAIS (Weschler, 1958); Auditory Acuity at 8 KHz, Divided Attention for Intermixed Stories; Recognition Memory for Names; Recognition of Faces; Health; Education (as measured using Hollingshead and Redlick, 1958); Physical Problems; and Perception of Physical Activity.

Analysis

Two separate analyses will be conducted. First, Principal Components Factor Analysis will be conducted on the battery of tests for the entire subject pool, and for the whites and minorites separately. Factor Structures (especially the variables and weights of variables defining the first factor) will be examined. Secondly, Multiple Regression Analysis will be performed,

regressing chronological age on the test battery. Again this analysis will be performed for the pooled sample, and for the whites and minorities separately. Reduced equations will be compared for all three analyses for differences. The specific aim of both analyses will be to compare the factor structures and regression equations of the pooled sample, and the two subsamples.

Results

The general composition of the sample is as follows: Total number of Whites is 81 with a mean age of 38.5 and range from 17 to 80. The total number of minorities is 84 with a mean age of 50.2 and a range from 18 to 79. The results of the principle components analysis is shown in Table 2. This table shows varimax rotated loadings for the pooled sample and for the subsamples. Four factors were extracted with eigenvalues greater than 1.0. Factor loadings in parenthesis (.40 or larger) are considered to be stable. In addition, percentage of variance accounted for by each factor is shown. For the present purposes, we are most concerned with the first factor (proposed to be a functional age factor), and the variables which define it. Three variables define the first factor for the pooled sample: WAISVOC (.77), PARTYFA (-.70), and EDUC (.78). Five variables define the first factor for the white subsample: DIGITBAC (.48), DB (.85), EDUC (-.47), PHYPROB (-.56), and PICALH (.78). Finally, five variables also define the first factor for the minority subsample: WAISVOC (.64), DB (.45), COMPH (.55), PARTYFA (-.72), and EDUC (.80). Comparing the white and minority first factors, only two of the five variables overlap, DB and EDUC, both with very discrepant loadings: (.85) vs. (.45) and (-.47) vs. (.80) respectively for whites and minorities. More importantly, comparison of the pooled sample structure with that of the minority and whites shows that (in

general), the pooled structure does not seem to be representative of either the white or the minority structures. There is one overlapping variable between the white and the pooled (EDUC, loading .78 for the total and -.47 for the whites). There is greater overlap between the minority and the pooled, with all three variables defining the pooled first factor also defining the minority first factor (WAISVOC loading .77 for pooled and .64 for minority, PARTYPA loading -.70 for pooled and -.76 for minority, and EDUC loading .78 for pooled and, .80 for minority). However, there are two additional variables loading on the minority first factor not loading highly on the pooled first factor (DB loading .45 and COMPH loading .55). Thus it seems that the first factors for the minority and the white subsamples are different from each other, and that the pooled sample first factor, while partially overlapping with the white subsample and more so with the minority subsample, is not strictly representative of the first factor structure of the separate subsamples.

The results of the multiple regression analyses are shown in Tables 3a-3c. These tables show standardized regression weights (beta weights) for all variables (Table 3A) for the pooled sample and separate subsamples. In addition to the overall regression, stepwise regressions were executed to discover which variables are responsible for the best prediction. These reduced equations are shown in Table 3B. The attempt to minimize multicollinearity within the test battery makes for better interpretation of the beta weights. However, comparison of statistical significance of weights from the subsamples to the pooled sample is less meaningful because of the larger number of degrees of freedom and thus greater power of the test for the pooled sample. However, because of the closer similarity in degrees of freedom for these statistical

tests between the two subsamples, these comparisons are possible. For the pooled sample, five variables have significant beta weights: DB (-.62), COMPH (-.18), PARTYFA (.14), EDUC (-.15), and PHYSACT (.13). For the white subsample, Three variables have significant beta weights: DB (-.63), COMPH (-.39), and PARTYFA (.24). Finally, for the minority subsample, eight variables have significant beta weights: DIGITBAC (-.25), ATTNFA (-.25), DB (-.53), COMPH (.17), HEALTH (.23), [illegible] (-.33), PHYPROB (.19), and PICALH (-.21). Comparison of the weights between the minority and white subsamples, as was true with the factor analysis, seems to show low comparability with respect to the variables with high beta weights. There are two overlapping highly weighted variables between the two subsamples (DB with beta weight -.63 for whites and -.53 for minorities and COMPH with beta weight -.39 for whites and .17 for minorities). A rough comparison of the subsamples to the pooled sample seems to show the opposite result obtained for the factor analysis. The white subsample's pattern of highly weighted variables seems more comparable to the pooled sample's pattern than does the minority subsample's. This is more accurately reflected in the reduced equations in Table 3C. The variables in the white reduced equation are completely contained in the pooled sample equation, with the same rank order of the beta weights. However, the equation for the minority subsample does not match (with a few exceptions) with the pooled sample regression equation. DB carries the highest beta weight for both equations. In addition, COMPH and DIGITBAC overlap, however rank second and fifth respectively in pooled sample (beta weights -.21 and -.12 respectively) and eighth and sixth respectively in the minority subsample (beta weights .17 and -.25 respectively.) Beyond this overlap, there are five variables in the minority subsample equation <u>not</u> in the

pooled sample equation and two in the pooled sample equation not included in the minority subsample equation. The high multiple R's indicate very good prediction of chronological age (R = .84 for the pooled sample, R = .84 for the white subsample, and R = 91 for the Minority subsample) and are not practically different from each other. Thus, while the end result prediction is very high and very similar across the three equations, the equations of the white and minority subsamples are quite different. In addition, while the pooled equation is very representative of the white subsample, it is not representative of the minority subsample.

An extension of this analysis is shown in Table 3C. In most research dealing with functional age, the pooled sample equation is used for defining functional age. Table 3C shows the results of minority and white stepwise regressions using only the variables which were identified in the initial pooled sample regression. These results confirm the earlier regression conclusions. The highly weighted variables for the pooled sample regression completely coincide (in a rank-order sense) with the white subsample. Comparison of the minority regression with the pooled sample regression shows that, while DB still carries the highest weight for both equations, the next two variables in the minority regression (DIGITBAC and PHYSACT) are the fifth and fourth highest weighted variables in the pooled regression. Again, the total multiple R's are very comparable. Thus, the earlier conclusion of noticeable differences between the minority and white subsamples, and between the minority subsample and the pooled sample is supported.

These two analyses discussed above suggest the appearance of differing factor structures and regression equations between minority and white

subsamples. In addition, they suggest that results from pooled sample analyses may not be representative of the separate subsample analyses.

In order to test these hypotheses statistically, two additional analyses were proposed. First, confirmatory factor analyses can be used to look at comparability of the factor structures (white, minority, and pooled), and representativeness of the pooled sample factor structure to the subsample factor structures. These analyses yield indices of the fit of one structure to another and can be compared with one another. Secondly, homogeneity of regression tests can be used to look at structural comparability of regression equations (white, minority, and pooled), and structural representativeness of the pooled regression equation to the subsample regression equations. However, a preliminary analysis comparing subgroup variance-covariance matrices revealed significant differences between groups on four of the twelve variables (WAISVOC, DIGITBAC, EDUCATION, and PHYPROB). In addition, a multivariate test of homogeneity of dispersion matrices (via MANOVA program) and a test of equality of group covariance matrices (via a discriminant function program) showed significant multivariate differences between subsample variance-covariance matrices. It is necessary to meet this assumption before undertaking the analyses discussed above. While it is true that these procedures are probably quite robust to departures from homogeneity of variance and homogeneity of covariance (and in the estimation of the author, variance differences were relatively small even though they were confirmed to be significant by very powerful multivariate tests) interpretation of the results of the two proposed procedures is quite difficult (e.g., the reasons for comparability or

noncomparability would not be exactly clear). It is for these reasons that the procedures were not reported.

Discussion

The results of the initial factor analysis and the regression analyses seem to indicate that the methods by which functional age has been assessed may be prone to traditional ethnic or cultural biases. The results of the factor analysis shows that if the pooled sample first factor is proposed to be indicative of a functional age factor, the variables which seem to define functional age (according to this definition) do not seem to represent the first factors of distinct ethnic groups. For example, if WAISVOC were used to compute an index of functional age based on the factor analysis, it would receive a high weight because it loads at (.77) or the pooled sample first factor. However, this variable does not load highly on the white subgroup first factor. Is the application of a large weight to WAISVOC appropriate for the average white individual when this variable seems to be reflecting another underlying dimension (perhaps orthogonal to the first functional age dimension)? For whites, this variable loads highly (.77) on the third factor, which seems conceptually distinct from the pooled sample first factor. Similarly, is it appropriate to give a small weight to a variable (e.g., PICALH) because it loads very low on the first factor of the pooled sample, when this variable carries heavy weight for whites in terms of defining the white subsample first factor? The argument seems to be that of deciding which first factor is the functional age factor and what are the variables which represent it. If principal components factor analysis of a battery of perceptual-cognitive and background variables yields a first factor which should represent functional age, then it

should do so regardless of the nature of the sample. While no research has preferred to compute functional age in this manner, Nuttall (1973) uses a factor analytic procedure to assess the number of dimensions of functional age and explicitly calls his first factor functional age. This argument becomes more clear in discussing the more often used regression approach to the measurement of functional age.

The regression approach has been used by a number of researchers (Dirken, 1972, Nuttall and his colleagues). The results of the regression analysis show that essentially five variables will be used in defining functional age for our battery based on a regression analysis of the pooled sample: Hearing, divided attention recognition memory (hits), memory for names (false alarm), physical activity, and digit span memory (the first three of which carry almost all the weight). Presumably, because of cultural influences on the aging process, different variables are age related for whites vs. minorities. The reason for this is not important for this discussion. However, if one's criterion for inclusion into the prediction equation is relationship with chronological age (because this is a proxy for functional age) then choice of variables may reflect the dominant cultural bias of the sample. If, for example, the first six largest correlations with chronological age are chosen for inclusion into the functional age equation based upon the pooled sample this would include: DB, PHYSACT, PARTYFA, COMPH, WAISVOC, and DIGITBAC (see Table 4). However, for minorities (in general), PARTYFA, COMPH, and WAISVOC are completely unrelated to chronological age which is contrary to the logic of the way functional age is to be indexed according to this model. Furthermore, when regression analyses are run and these non-optimal weights (for minorities) are used, considerable

shrinkage in the multiple R is to be expected, leading to greater variability around the regression line for the group against which variable selection is biased. Thus, actual chronological ages for the minority group will be (in general) more different (variable about the regression line) from their predicted ages. This phenomenon is not caused by environmental, physical, or physiological factors as would be expected or interpreted from a theory of functional age, but simply as a function of choice of relevant functional age indicator variables. While shrinkage is true of any optimal weighting strategy due to the operation of chance factors in the sample, the shrinkage referred to above is shrinkage due to systematic sample characteristics which serve to moderate variable-chronological age correlations. At this point, it is not intuitively obvious what variables might moderate the relationship between another variable (e.g., a cognitive test) and chronological age, perhaps physical ability or another such variable.

There are potential limitations and shortcomings of the present study. First, how important are violations of homogeneity variance and homogeneity of covariance in interpreting and comparing subsample beta weights and factor loadings? With marked differences in variation (e.g., ratios of nine to one) it is not clear whether a difference between whites and minorities beta weights of the same variable would be due to the difference (between the whites and the minority) between correlations of that variable with the criterion variable, or to differences between the extent of criterion and/or predictor variation. There was quite a difference in the average age between the whites and minorities, with the minority group being substantially older on the average. This may also have contributed to the variance differences since variability

tends to increase with age (indeed, the minority group variances were consistently larger than the white group). Secondly, the combining of Hispanic and Black subjects into the minority subsample may have affected these results in some unforseeable way. Finally, the relatively small sample sizes make the results somewhat tentative (we are attempting to secure funding to obtain more data). However, given the above limitations, the study does point out important issues to be addressed.

Issues

One issue to be concerned about is the issue of cultural hetreogeneity. Cultural heterogeneity cannot be ignored in attempting to assess and develop indices of functional age. The impact of these variables must be looked at in the context of their influence on actual measurement practices. A second issue, and perhaps the most important consideration, is that there are a great many problems with the current ways of indexing functional age (including the possibility of building in race or ethnic bias). Researchers have questioned the regression approach on statistical and logical/theoretical grounds (Costa and McCrae, 1981). Research must be done to investigate the shortcomings of this approach (e.g., in choice of variables to include in ones definition of functional age) and suggest new methods (e.g., profile analysis of Heron & Chown, 1967) or modifications in the old methods. It seems that more theoretical work is necessary in this area in deciding what functional age really means. At this point, a system of measurement can be developed with the identification of appropriate criteria of measurement and the analysis of proper approaches. For example, McFarland (1953) discussed functional age in terms of "reserve capacity." Current work is under way by the authors on the

development of a "signal-detection" model of assessing the amount of "slack" contained in the various physical and psychological systems which are deemed useful in assessing functional age. A final issue is the issue of the utility and practicality of functional age.

Functional age, as proposed by McFarland (1953, 1973) may be useful for making decisions about retirement, placement, and retraining of older workers. Functional age may have the greatest utility in situations where past reliance on chronological age has been heavy (e.g., retirement). It might also be useful as a tool for making hiring decisions. As discussed earlier, the initial analyses using functional age to predict self evaluations of job performance showed different prediction equations for whites and minorities, as well as differing factor structures. The important point here, is that if a measure of functional age is developed for use in industrial or applied settings it must be cultural free. In addition, the use to which it is put must also be free from potential discriminatory influences. This fact may not be readily foreseeable. Thus, it seems that there are two concerns with the applied use of functional age. First, has the functional age index or yardstick been constructed in a culture-free manner (e.g., variables chosen for inclusion exhibit similar correlations with age, or another suitable criterion for different ethnic groups)? The second concern is perhaps the most complicated (and dangerous). If certain environmental, cultural, genetic (or what have you) factors serve to inflate or depress scores on the various functional age component measures, then this will directly influence computed functional age. If ethnicity is related to any of the above factors, then those people of that particular ethnic group will have "worse" functional ages (in relation to their chronological ages) than

another group. Finally, if functional age is used in place of chronological age (e.g., in making retirement decisions), then overall, more of one ethnic group will be retired than another group (all else being equal). The next question to be answered, is whether or not this might be considered to be evidence of discriminatory practice (e.g., under Title VII of the 1964 Civil Rights Act). Also, is this situation analogous to using a selection device which exhibits adverse impact, and what is the potential effect of using pure measures of physical, physiological, and cognitive ability (as in functional age) vs. use of some heterogeneous selection device? While these issues may seem far off at the present, in order for functional age to be used in situations such as these, it must conform to established practices (as must chronological age).

Conclusion

The intuitive appeal of the concept of functional age cannot be denied. It is consistent with the methods of science to attempt to improve upon the use of chronological age as an index of individual functioning. Relatively little research has been done and past research has proved to be lacking in many ways. Additional theoretical work needs to be done before an appropriate measurement methodology can be developed and tested. In addition, the research focus must be broadened to include potential uses of a concept of functional age and what influences would the use of such an index have on current work practices as well as future work and work-related issues.

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Table 1

Final Battery of Tests

WAISVOC.	This is the WAIS vocabulary subtest.
DIGITBAC.	This is the WAIS Backward Digitspan subtest.
ATTNFA.	This was a subtest designed to tap divided attention recognition memory. Subjects viewed two stories, one embedded in the other, and concentrated only one one story. They were then asked yes-no word recognition questions from both stories. This variables is the number of false alarms recorded for the attended-to story.
COMPH.	(Same procedure as with ATTNFA above) Subjects were also asked yes-no comprehension questions asking about consistency of statements with the attended-to story. This variable is the number of hits recorded.
PARTYFA.	This was a subtest designed to tap memory for common names. Groups of mames were presented in increasing numbers, and subjects gave yes-no answers to the presence or absence of a target name. This variable is the number of false alarms recorded.
DB.	This was simply a composite variable of left and right ear hearing at 8 kHz.
PICALH.	This was a subtest designed to tap recognition memory for faces. subjects viewed a set of pictures, and then were presented with a new set of pictures (some repeats and some new). They were to respond with whether or not the picture was new or old. This variable is the number of hits recorded.
PICALFA.	(Same procedure as with PICALH above) This variable is the number of false alarms recorded.
HEALTH.	This is the subjects self-reported current health status.
EDUC.	Formal education measured using the Hollingshead and Redlick (1958).
PHYPROB.	This is a composite variable of yes-no responses referring to problems with the following: Heart, Blood Pressure, Circulation, Weight, on Medication, Smoking, and Drinking.
PHYSACT.	This is the subjects self-reported amount of current physical activity

Table 2.

Results of Principal Components analysis with Varimax rotation for the pooled, white, and minority samples[1]

	Factor I			Factor II			Factor III			Factor IV		
Variables	Pool	Wh	Min	Pool	Wh	Min	Pool	Wh	Min	Pool	Wh	Min
WAISVOC	(.77)	.23	(.64)	.18	.18	.14	.03	(.77)	-.01	-.10	.10	(-.51)
DIGITSAC	.31	(.48)	.21	(.61)	.39	(.61)	.33	(.39)	.11	-.19	000	(-.44)
ATTNFA	-.11	.08	-.13	.03	(.53)	-.02	.00	(-.40)	.00	(.78)	.35	(.83)
DB	.21	(.85)	(.45)	(.43)	.14	-.19	.04	.00	(-.39)	(.48)	.06	.30
COMPH	.14	.22	(.55)	.07	.16	-.04	.14	(-.74)	(.46)	(.67)	.04	.37
PARTYFA	(-.70)	.09	(-.72)	-.11	(-.72)	-.35	-.01	.08	.16	-.17	.25	.06
HEALTH	.10	.25	.01	.02	(.71)	-.07	(.75)	.13	(.78)	.12	.07	-.15
EDUC	(.78)	(-.47)	(.80)	-.04	(.40)	.10	.19	.36	.09	.06	.10	-.25
PHYPROB	.15	(-.56)	.05	-.18	-.09	-.18	(-.76)	.21	(-.76)	.21	.15	-.09
PHYSACT	-.19	-.29	-.02	-.01	.04	(-.40)	(-.57)	.10	-.17	.09	(.75)	.30
PICALFA	-.16	.38	-.01	(.72)	.01	(.84	.04	-.06	.12	-.02	(.71)	.04
PICALH	.28	(.78)	.38	(.78)	-.03	(.70)	.01	.21	-.22	.16	.16	.06
% Variance	23.4	22.4	26.0	12.8	14.5	14.9	11.0	12.8	11.4	10.3	10.8	10.1

[1]Variables in parentheses load greater than .40

Table 3a.

Results of multiple regression analysis on pooled, white and minority samples. Tabled elements are standardized regression coefficients (beta weights).

Variables	Pooled	White	Minority
WAISVOC	.11	.08	.00
DIGITBAC	-.13	.01	-.25**
ATTNFA	-.03	.13	-.25**
DB	-.62***	-.63***	-.53***
COMPH	-.18**	-.39***	.17*
PARTYFA	.14*	.24*	.06
HEALTH	.12	-.02	.23*
EDUC	-.15*	-.08	-.33**
PHYPROB	.01	-.06	.19*
PHYSACT	.13*	.11	.08
PICALFA	.07	-.01	.16
PICALH	-.12	-.08	-.21*
Multiple R	.85	.86	.92

* $p < .05$
** $p < .01$
*** $p < .001$

Table 3b.

Results of stepwise multiple regressions. Reduced equations for pooled white and minority samples[1]

Sample	Variable	Beta	F Ratio	Multiple R
Pooled	DB	-.67	128.11***	
	COMPH	-.21	12.87***	.836
	PARTYFA	.18	8.72**	
	PHYSACT	.15	6.24*	
	DIGITBAC	-.12	3.98*	
White	DB	-.63	63.24***	
	COMPH	-.37	21.81***	.841
	PARTYFA	.21	7.60**	
Minority	DB	-.53	31.95***	
	EDUC	-.38	15.29***	
	ATTNFA	-.26	9.65**	
	HEALTH	.23	6.85*	.911
	PICALH	.23	6.80*	
	DIGITBAC	-.25	6.66*	
	PHYPROB	.19	4.70*	
	COMPH	.17	4.40*	

[1]Variable entry is stopped when no additional variable beta weights reach significance at $p < .05$ upon entry into the equation.

* $p < .05$
** $p < .01$
*** $p < .001$

Table 2c.

Results of stepwise multiple regressions using only the variables in the reduced equation of the pooled sample, for the pooled, white, and minority samples.

Sample	Variable	Beta	F Ratio	Multiple R
Pooled	DB	-.67	128.11***	
	COMPH	-.21	12.87***	
	PARTYFA	.18	8.72**	.836
	PHYSACT	.15	6.24*	
	DIGITBAC	-.12	3.98*	
White	DB	-.53	53.22**	
	COMPH	-.42	30.89***	
	PARTYFA	.19	6.44*	.810
	PHYSACT	.06	.68	
	DIGITBAC	.07	.66	
Minority	DB	-.74	76.46***	
	DIGITBAC	-.33	14.85***	
	PHYSACT	.19	4.85*	.800
	COMPH	-.10	1.45	
	PARTYFA	.11	1.63	

* $p < .05$
** $p < .01$
*** $p < .001$

Table 4.

Rank order of correlations between the 12 tests and chronological age for the pooled, white, and minority samples.

Pooled		White		Minority	
DB	(-.71)***	DB	(-.67)***	DB	(-.70)***
PHYSACT	(.53)***	COMPH	(-.60)***	DIGITBAC	(-.44)***
PARTYFA	(.39)***	PHYSACT	(.27)**	EDUC	(-.38)***
COMPH	(-.37)***	DIGITBAC	(-.27)**	PHYSACT	(.36)**
WAISVOC	(.36)***	WAISVOC	(.25)*	HEALTH	(.30)**
DIGITBAC	(-.33)***	PICALFA	(-.19)	PICALH	(-.24)*
PHYPROB	(-.29)***	HEALTH	(-.16)	PICALFA	(-.14)
PICALH	(.21)**	EDUC	(.15)	PHYPROB	(-.10)
ATTNFA	(-.20)*	ATTNFA	(-.14)	WAISVOC	(.10)
HEALTH	(.16)	PICALH	(-.13)	ATTNFA	(-.07)
PICALFA	(-.15)	PHYPROB	(.08)	PARTYFA	(-.03)
EDUC	(.05	PARTYFA	(-.06)	COMPH	(.01)

* $p < .05$
** $p < .01$
*** $p < .001$